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Phytoplankton community in relation to physicochemical characteristics of Renuka Lake and Parshuram Tal (H.P.), India

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ABSTRACT

The study revealed that the average temperature of Renuka Lake ranged between 13.83±4.45°C to 19.83±1.33°C while, in Parshuram Tal it varied from 14.00±1.41°C to 19.50±0.71°C. The average dissolved oxygen in Renuka Lake was 7.12±0.66 mg l^{-1} to 9.80±2.60 mg l^{-1}, whereas, in Parshuram Tal it was recorded between 6.55±0.49 mg l^{-1} to 12.00±2.83 mg l^{-1}. A total of 28 genera of phytoplankton were identified from the Renuka Lake and 24 genera from Parshuram Tal. *Closterium, Gonatozygon, Stephnodiscus* were dominant genera in Renuka Lake while *Gonatozygon, Volvox* were dominant in Parshuram Tal. *Chlorella, Fragillaria, Eunotica* and *Amphora* were present only in Renuka Lake. Based on the qualitative analysis, chlorophyceae was dominant group in both lakes. In Renuka Lake, density ranged in between 108.0 units l^{-1} – 648.0 units l^{-1}, while in Parshuram Tal it varied from 40.0 units l^{-1} – 382.0 units l^{-1}. In Renuka Lake and Parshuram Tal Shannon-Wiener index calculated indicates that the water fall in the range of polluted to clean water.

KEYWORDS: Phytoplankton, density, diversity, physicochemical, Renuka Lake, Parshuram Tal.

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INTRODUCTION

Water is a necessity for all living beings, without it; there would be no life. Most of the biological phenomena take place in water medium. Globally, freshwater has become the fastest depleting natural resource now days. Phytoplanktons are vital and important organisms which act as producer to the primary food supply in any aquatic ecosystem. They are the initial biological components from which then energy is transferred to higher organisms through food chain [1, 2]. The presence of phytoplankton in any water body can lead to productive and sustainability of that water body. The assemblage in the form of composition and distribution is dependent on the physical, chemical and biological properties of water [3]. The physico-chemical parameters are the major factors that control the dynamics and structure of the phytoplankton of aquatic ecosystem [4]. Variations in these parameters have an important role in the distribution, periodicity and quantitative and qualitative composition of freshwater biota. Dissolved oxygen has been used as a most reliable parameter of lake eutrophication [5]. Different physico-chemical parameters of water are very important for effective maintenance of water quality through appropriate control [6]. World over, the lakes have been subjected to investigations on varied aspects [7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17]. But only few studies were carried out in lakes of Himachal Pradesh [18, 19, 20, 21]. The present study was conducted to know the status of Renuka lake and Parshuram Tal, as hundreds of tourists/people approached these lakes through-out the year.

MATERIALS AND METHODS

***Study Area*:** The Renuka wetland is surrounded by lush green forest and has two water body, one is the main Renuka Lake (20 ha) and the other one, comparatively smaller, is known as Parshuram Tal. Parshuram Tal receives water from the main Renuka Lake through a small graveled channel. Renuka Lake is about 1050m in length 204m in width from its broadest point and depth varies up to 13m. Length of Parshuram Tal is 173m and width is 160m (approx). Sampling for ascertaining the diversity and density of Phytoplankton and physicochemical characteristics along with the of Renuka Lake was conducted at six sampling sites i.e.,S1, S2, S3, S4, S5 and S6, while Parshuram Tal was conducted at two sampling sites i.e., S7 and S8 during the present study (Figure 1).

Figure 1. Ariel view of Renuka Lake and Parshuram Tal (Source: Google Earth)

Phytoplankton and Physicochemical analysis: Monthly sampling was carried out to collect data on phytoplankton community and selected physicochemical parameters and of the lakes during December 2013 to May 2014. Phytoplankton samples were collected by filtering 100 litre of water through phytoplankton net and preserved in 4% formalin. Further analysis was done in laboratory. Phytoplankton were identified up to the lowest recognizable taxonomic unit mostly genus following keys by [22, 23, 24]. Phytoplanktons were enumerated using Sedgwick-Rafter Cell Counter [25]. Physicochemical parameters were studied following standard methods [25, 26, 27]. Phytoplankton density was subjected to further analysis by applying the Shannon-Wiener species diversity index [28] Margalef (richness) index Evenness index and Palmer index.

RESULT AND DISCUSSION

The average temperature of Renuka Lake ranged between 13.83±4.45^{o}Cand 19.83±1.33^{o}C and in Parshuram Tal it ranged between 14.00±1.41^{o}C and 19.50±0.71^{o}C, while, average water temperature of Renuka Lake ranged between 11.00±2.37^{o}C and 17.17±2.32^{o}C, in Parshuram Tal it was maximum 12.50±2.12^{o}C and 19.50±0.71^{o}C (Table 1). Temperature is a very important abiotic factor. In any aquatic ecosystem, it not only governs the metabolic and physiological behaviour of the inhabiting organisms but also has a profound influence on other physico-chemical parameters thereby affecting various physical and chemical processes occurring within the lake ecosystem [25, 29]. The fall in air temperature during winter months may be attributed to the shorter day length/photoperiod and oblique incident rays. The increase in air temperature during March to May may be attributed to increased day/photoperiod, vertical incident rays and heating up of atmosphere as a result of absorption of heat by suspended particles [25, 30, 31].

The average dissolved oxygen in Renuka Lake water ranged between 7.12±0.66 mg l^{-1} and 9.80±2.60 mg l^{-1}. In Parshuram Tal it was recorded between 6.55±0.49 mg l^{-1} and 12.00±2.83 mg l^{-1} (Table 1). Higher values in DO content (February'14) could be attributed to the optimal day length and light intensity for photosynthesis [32], Decline in DO values during early spring in both lakes could may be attributed to increase in day length and light intensity which after having acquired the optimal factor for photosynthesis and tends to decrease DO production.

The average bicarbonate alkalinity of Renuka Lake ranged from 52.0±19.43 mg l^{-1} to 70.00±25.30 mg l^{-1}. In Parshuram Tal it varied from 35.00±7.07 mg l^{-1} to 87.50±3.54 mg l^{-1}. The average carbonate alkalinity was observed at site S3 in Renuka Lake 20.00±0.0 mg $l^{-1}$to 40.00±0.00 mg l^{-1}. Carbonates alkalinity was reported at Site S3. It was may be due to the removal of carbon dioxide by photosynthesis of plants (microbes, algae, floating phytoplankton, macrophytes) and less commonly by changes in temperature, evaporation or mixing of water masses, resulting in the precipitation of low-Mg calcite [33]. Bicarbonate alkalinity in a water body is a measure of its buffering capacity. It is added to water system as a result of surface runoff during rains either through soil or rocks containing bicarbonate minerals [34].

The average pH of Renuka Lake varied from 7.57±0.41 to 7.70±0.32, while in Parshuram Tal pH ranges in between 7.80±0.00 to 8.00±0.00 (Table 1). The average transparency of Renuka Lake and Parshuram Tal fluctuated in between 37.00±6.32 cm to 38.50±0.00 and 28.50±0.71 cm to maximum 31.00±2.83, respectively (Table 1). Decline of water transparency in winter months could also be assigned to mixing of lower layers of lake water with upper layers as a result of lake overturning during these months. This is in agreement with the observation of Sehgal [35]. A total of 28 genera of phytoplankton were identified from the Renuka Lake, these belonged to 20 families of 10 orders and 3 classes whereas from Parshuram Tal 24 genera belonged to 17 families of 10 orders and 3 classes during the study period (Table 2). The highest number of phytoplanktonic genera in Renuka Lake and Parshuram Tal belonged to class chlorophyceae (18 and 16) followed by bacillariophyceae (9 and 7), and myxophyceae (1 and 1), respectively. In Pong Wetland in Himachal Pradesh 24 species of phytoplankton were reported [36]. While in Dal Lake of Kashmir 35 species of phytoplankton were identified [7]. In Garhwal, 36 species of phytoplankton from reported from Deoria Tal [12], whereas, 22 genera of phytoplankton belonging to 16 families of 6 orders and 4 classes were recorded from Dodi Tal [14].

The total density of phytoplankton of Renuka Lake ranged from 108.0 unit l^{-1} to 684.0 unit l^{-1}. The total density of phytoplankton of Parshuram Tal ranged from 40.0 unit l^{-1} to 382.0 unit l^{-1}. The variations of different group of phytoplankton in all sampling site were presented in table 3. *Closterium, Gonatozygon, Stephnodiscus* were dominant *Chlorella, Volvox, Eunotia* was sub

dominant. Pleodorina, *Richterilla, Mougetia, Ulothrix, Amphora, Synedra* were frequent and *Penium, Scendesmus* were rare in Renuka Lake. In Parshuram Tal *Gonatozygon, Volvox* was dominant. *Oscillatoria* was sub dominant. *Navicula, epithemia. Scendesmus* were frequent and *Pleodorina, Rhizoclonium, Penium* were rare phytoplankton

The green algae (Chlorophyceae) had largest contribution followed by diatoms (Bacillariophyceae) and Myxophyceae. *Spirogyra* (chlorophyceae) was dominant in winter. Similarly, it was reported dominant in Pong Wetland in Himachal Pradesh [36]. *Pediastrum* species of chlorophyceae was frequently observed during the study period, it has been reported that *Pediastrum* species are more common in eutrophic water than in oligotrophic water [37]. Chlorophyceae dominancy was related with cleaning of lake water [38]. Lake fertility is also correlated with algal group [39]. In the lake of low fertility the phytoplankton was dominated by diatoms and chlorophyceae but in eutrophic lakes, cyanophyceae predominated. Both Renuka Lake and Parshuram Tal was dominated by chlorophyceae and diatoms during the study period thus both lakes fall under the category of oligotrophic lake. In Renuka Lake among the phytoplankton, chlorophyceae was the dominant class (53.70%), followed by bacillariophyceae (43.70%) and myxophyceae (2.59%) (Figure 2). While, in Parshuram Tal chlorophyceae constituted 57.54% of the phytoplanktonic community, followed by bacillariophyceae (29.10%), and myxophyceae (13.36%) (Fig 2). Highest percentage contribution by chlorophyceae followed by bacillariophyceae in the Garhwal Himalayan lakes was also reported by some workers [12, 14].

The Shannon-wiener diversity index calculated varied between 0.774 to 3.049 in Renuka Lake, Whereas, in Parshuram Tal it varied between 0.485 and 2.340 (Table 4).The phytoplankton species richness of Renuka Lake was recorded between 2.073 and 6.537, Whereas, in Parshuram Tal, it ranged between 2.573 and 7.770 (Table 3). The evenness index of phytoplankton of Renuka Lake varied between 0.253 and 0.962, while, in Parshuram Tal it varied between 0.153 and 0.738 during the study period (Table 4).

The values of less than 1 are interpreted as heavily polluted, 1-3 as moderately polluted and more than 3 as clean water [40]. Shannon-wiener diversity index ($\overline{H}$) almost near to 3 for phytoplankton suggests that water is good for growth of phytoplankton in water body [41]. During the study period it was observed that in Renuka Lake and Parshuram Tal Shannon-Wiener index calculated indicated that the water fall in the range of polluted to clean water due to highly influx of tourist during summer season and low in winter.

Relative species abundance in a community is another factor that affects diversity [42, 43]. It is measured with a standardized index of species abundance (evenness or equatability) that is typically

on a scale ranging from near 0, which indicates low evenness or high single-species dominance, to 1, which indicates equal abundance of all species or maximum evenness [44, 45]. Evenness value takes between 0 and 1, with 1 being complete evenness [46]. The index applied to the present study indicated that individuals of the phytoplankton community in Renuka Lake and Parshuram Tal are not evenly distributed as the values ranged from 0.253 to 0.962 and 0.153 to 0.738, respectively.

For the calculation of Palmer index, table is taken in use. This table no. 4 provides 20 algal genera most tolerant to organic pollution and a number is assigned to each of them depending on their relative tolerance [47]. The algae present in a water sample are identified and the genera present from this list are noticed (other genera are ignored). An algae is called present when 50 or more individuals of it are present in one ml of water. The numbers scored by each genera are totalled to get the value of algal genus index. A score of 20 or more for a sample is indication of organic pollution, while a score of 15 to 19 is taken as probable evidence of high organic pollution (Table 5). Lower figure indicates that the organic pollution is not high or the sampling has not been representative.

In the present study period the value of palmer index of Renuka Lake ranged in between 17 to 18 score, whereas, in Parshuram Tal value of palmer index ranged in between 7 to 11 (Table 6). Therefore, from the above values it is indicated that Renuka Lake is taken as probable evidence of high organic pollution due to the reason that in Renuka Lake, there is human interference in the form of boating and regular bathing, while, some sites of Renuka Lake evidence with inflow of the soil erosion and dry leaves of the surrounding trees. In Parshuram Tal there is no organic pollution as no human interference is observed there during the present study period.

Table 1. Variation in physicochemical parameters in Renuka Lake and Parshuram Tal (during the study period [Mean±SD].

	Renuka Lake		**Parshuram Tal**	
	Minimum	**Maximum**	**Minimum**	**Maximum**
Air temperature (^{o}C)	13.83±4.45	19.83±1.33	14.00±1.41	19.50±0.71
Water Temperature (^{o}C)	11.00±2.37	17.17±2.32	12.50±2.12	19.50±0.71
Dissolved oxygen (mg l^{-1})	7.12±0.66	9.80±2.60	6.55±0.49	12.00±2.83
Carbon dioxide (mg l^{-1})	1.71±0.81	2.52±1.37	1.87±0.06	2.42±0.62
Bicarbonate Alkalinity (mg l^{-}	52.0±19.43	70.00±25.30	35.00±7.07	87.50±3.54
Carbonate Alkalinity (mg l^{-1})	20.00±0.0	40.00±0.00	---	---
pH	7.57±0.41	7.70±0.32	7.80±0.00	8.00±0.00
Salinity (mg l^{-1})	0.28±0.08	0.38±0.09	0.33±0.04	0.40±0.14
Transparency (cm)	37.00±6.32	38.50±0.00	28.50±0.71	31.00±2.83

Table 2. Checklist of phytoplankton recorded from Renuka Lake and Parshuram Tal during the study period.

Class	Order	Family	Genus	Genus
			Renuka Lake	**Parshuram Tal**
Chlorophyceae	Zygnematales	Desmidiaceae	*Closertium*	*Closertium*
			Cosmarium	*Cosmarium*
			Staurastrum	*Staurastrum*
			Penium	*Penium*
		Mesotaeniaceae	*Gonatozygon*	*Gonatozygon*
		Zygnemataceae	*Mougeotia*	*Mougeotia*
			Spirogyra	*Spirogyra*
	Chlorococcales	Oocystaceae	*Chlorella*	-
		Scenedesmaceae	*Scenedesmus*	*Scenedesmus*
		Hydrodictyaceae	*Pediastrum*	*Pediastrum*
		Microcystaceae	*Microcystis*	*Microcystis*
	Ulotrichales	Microporaceae	*Microspora*	*Microspora*
		Uloyhrichasceae	*Ulothrix*	*Ulothrix*
	Volvocales	Volvocaceae	*Pleodorina*	*Pleodorina*
			Volvox	*Volvox*
	Cladophorales	Cladophoraceae	*Rhizoclonium*	*Rhizoclonium*
			Richterilla	-
Bacillariophyceae	Bacillariales	Fragillariaceae	*Fragillaria*	*Fragillaria*
			Diatoma	*Diatoma*
		Eunotiaceae	*Eunotica*	-
		Naviculaceae	*Navicula*	*Navicula*
		Cymbellaceae	*Amphora*	-
		Epithemiaceae	*Epithemia*	*Epithemia*
	Melosirales	Melosiraceae	*Melosira*	*Melosira*
	Thalassiosirales	Stephanodiscaceae	*Stephnodiscuss*	*Stephnodiscuss*
	Fragilariales	Fragillariceae	*Synedra*	*Synedra*
Myxopyhceae	Nostocales	Chlorococceacceae	*Oscillatoria*	*Oscillatoria*

Table 3. Classs-wise density and Total density of phytoplankton of Renuka Lake and Parshuram Tal [in unit l^{-1}].

	Renuka Lake		**Parshuram Tal**	
	Minimum	**Maximum**	**Minimum**	**Maximum**
Chlorophyceae	58.0	474.0	30.0	224.0
Bacillariophyceae	38.0	356.0	4.0	228.0
Myxophyceae	2.0	30.0	10.0	64.0
Total Density	**108.0**	**684.0**	**382.0**	**40.0**

Table 4. Diversity index (*H'*), Richness (d') and Evenness (e) of phytoplankton of Renuka Lake and Parshuram Tal during the study period.

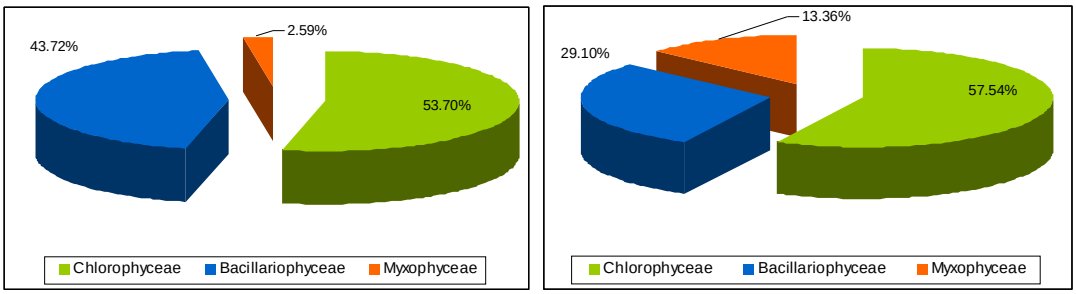
	Renuka Lake		Parshuram Tal	
	Minimum	**Maximum**	**Minimum**	**Maximum**
H'	0.774	3.049	0.485	2.340
d'	2.073	6.537	2.573	7.770
e	0.253	0.962	0.153	0.738

Table 5. Pollution index of algal genera (Palmer, 1969).

Genera	Pollution index	Genera	Pollution index
Anacystis (microcystis)	1	Micractinium	1
Arkistrodesmus	2	Navicula	3
Chlamydomonas	4	Nitzschia	3
Chlorella	3	Oscillatoria	4
Closterium	1	Pandorina	1
Cyclotella	1	Phacus	2
Euglena	5	Phormidium	1
Gomphonema	1	Scenedesmus	4
Lepocinclis	1	Stigeoclonium	2
Melosira	1	Synedra	2

Table 6. Palmer Index of phytoplankton of Renuka Lake and Parshuram Tal during the study period.

	Palmer Index	
Name of Months	**Renuka Lake**	**Parshuram Tal**
December' 13	17	8
January' 14	18	11
February' 14	18	10
March' 14	18	9
April' 14	18	7
May' 14	18	7



Renuka Lake Parshuram Tal

Figure 1. Percentage fluctuation of phytoplankton in Renuka Lake and Parshuram Tal during the study period.

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REFERENCES

1. Tiwari A, Chauhan SVS. Seasonal phytoplanktonic diversity of Kitham Lake, Agra. J. Environ. Biol. 2006; 27: 35–38.
2. Saifullah ASM, Hena MKA, Idris MH, et al. Diversity of phytoplankton from mangrove Estuaries of Sarawak, Malaysia. World Appl. Sci. J. 2014; 31: 915–924.
3. Patil RSK, Patil SS, Sathe TV. Occurrence of phytoplankton in major freshwater bodies of Ajara tahsil, Kolhapur district (MS), India. Asian Academic Research Journal of Multidisciplinary. 2015; 1(31): 35-45
4. Hulyal SB, Kaliwal BB. Dynamics of phytoplankton in relation to physico-chemical factors of Almatti reservoir of Bijapur district, Karnataka State. Environ. Monit. Assess. 2009; 153: 45–59.
5. Kaul V, Handoo JK, Raina R. Physicochemical characteristics of Nilnag-a high altitude forest lake in Kashmir and its comparison with valley lakes. Proc. Indian National Sci. Acad. B. 1980; 46(4): 528-541.
6. Adak MD, Adak S, Purohit KM. Studies on water quality of village Timjore, Orissa. I. Physico-chemical parameters. Indian J. of Envntl. Prtcn. 2002; 22(9): 1040-1046.
7. Das SM, Daftario S, Singh H, et al. Studies on organic production of high altitude lakes of India. Part I: The general ecology and zooplankton of Kashmir lakes, Kounsarang and Alpather, with correlation of plankton volume, pH and temperature of Dal Lake. Kashmir Science. 1969; 7(1- 2): 119-132.

8. Das SM, Akhter S. Ecology of high altitude lakes of Kashmir. Ichthyologica. 1971; 10 (1-2): 6-12.
9. Zutshi DP, Vass KK. Variation in the water quality of some Kashmir lakes. Trop. Ecology. 1973; 14: 182-196.
10. Schindler DW, Mills KH, Malley DF, Findlay DL, et al. Long-term ecosystem stress: the effect of year of experimental acidification on a small lake. Science. 1981; 228: 1395-1401.
11. Willen E, Hajdu S, Pejler Y. Summer classification in 73 nutrient poor Swedish lakes. Classification, ordination and choice of long-term monitoring objects. Limnologica. 1990; 20: 217-227.
12. Rawat MS, Sharma RC. Phytoplankton population of Garhwal Lake Deoria Tal, Uttaranchal. J. ecophysiol. Occup. Hlth. 2005; 5: 73-76.
13. Akoma OC, Imoode TOT. Limnological and phytoplankton survey of Bahir dar gulf of Lake Tana, Ethopia. African Journal of Science and Technology. 2009; 10(2): 91-98.
14. Rawat MS, Singh D, Bantwan B, et al. Diurnal variation in physicochemical characteristics and phytoplankton population density of high altitude lake Dodi Tal, Uttarakhand. Ecology Environment and Conservation. 2012; 18 (2): 273-278.
15. Dixit AK, Pandey SK, Mehta R, et al. Study of physico-chemical parameters of different pond water of Bilaspur District, Chhattishgarh, India. Environmental Skeptics and Critics. 2015; 4(3): 89-95.
16. Qureshimatva UM, Maurya RR, Gamit SB, et al. Determination of Physico-Chemical Parameters and Water Quality Index (Wqi) of Chandlodia Lake, Ahmedabad, Gujarat, India. Environ Anal Toxicol. 2015; 5: 4.
17. Singh D, Rawat MS, Gusain OP. Primary Productivity in Nachiketa Tal, a high altitude lake of Garhwal Himalayas (India). European Academic Research. 2016; IV (8): 6462-6478.
18. Singh R, Sharma G. Phytoplankton and water quality of Dashair, an ice covered lake of Himachal Pradesh. Uttar Pradesh J. Zool. 1985; 6(1): 64-68.
19. Singh R. Cultural impact on fish fauna of Rewalsa lake, Himachal Pradesh. Uttar Pradesh J. Zool. 1986; 6(1): 64-68.
20. Das BK, Kaur P. Major ion chemistry of Renuka lake and weathering processes, Sirmaur District, Himachal Pradesh, India. Environmental Geology. 2001; 40 (7): 908-917.
21. Negi RK, Johal MS, Tarana. Diversity of phytoplankton and zooplankton of Pong wetland in Himachal Pradesh. Him. J. Env. Zool. 2004; 18(2): 159-163.
22. Needham JG, Needham PR. A Guide to the study of Fresh water Biology. 5th ed. Dey inc: Sam Francisce; 1962.

23. Ward HB, Whipple GC. Fresh water Biology, W.T Edmondson. 2nd ed. John willey and willey and Sons: Inc. N. York; 1959.
24. Sarode PT, Kamat ND. Freshater Diatoms of Maharashtra. Saikripa Prakashan Aurangabad; 1984.
25. Welch PS. Limnology: 2nd ed. McGraw Hill book Company: New York, Toronto and London; 1952.
26. Trivedy RK, Goel PK. Chemical and Biological Methods for Water Pollution Studies Environmental Publications, Kharad; 1986.
27. APHA. Standard Methods for the Examination of Water and Waste Water, 19th ed. American Public Health Association: Washington D.C. New York; 1995.
28. Shannon CE, Wiener W, The Mathematical Theory of Communication. Urbana University of Illinois Press; 1963.
29. Clarke WJ. The phytoplankton of the Logon river, Utah, a mountain stream. Diss. Abstr. 1959; 21(6): 1339.
30. Munawar M. Limnological studies of freshwater ponds of Hyderabad, India. I–Biotope. Hydrobiol. 1970; 35: 127-162.
31. Sharma A. Limnological studies on Ban – Ganga and distributions pattern of stream bottom fauna. Ph.D. Thesis, University of Jammu. 1999.
32. Qadri MY Yousuf AR. Limnological Studies on Lake Malpur Sar. I. The Biotype GEOBIOS, 1980; 7: 117 – 119.
33. Flugel E. Microfacies of Carbonate rocks: Analysis, Interpretation and Application. 2nd Edition, Springer – Verlag, Berlin Heidelberg. 2010; 984.
34. Ram HK, Mohan MR, Chittanagiri N et al. Water quality studies on freshwater lakes of Kolar Taluk, Kolar, Karnataka. In: Environmental issues and solution. Kumar A. and Roy P.K. (eds.), Daya Publishing House, 2008; 131-139.
35. Sehgal HS. Limnology of Lake Surinsar, Jammu, with reference to zooplankton and fishery prospects. Ph.D. Thesis, University of Jammu, Jammu. 1980
36. Negi RK, Johal MS, Negi T. Study of the physico-chemical parameters of water of Pongdam reservoir, Himachal Pradesh: A Ramsar site. Him. J. Env. Zool. 2006; 20(2): 247-251.
37. Hutchinson GE. A Treatise on Limnology. Vol. II, Introduction to Lake Biology and the Limnoplankton. New York: John Wiley and Sons, Inc. Rawson, D.S., 1956. The net plankton of Great Slave Lake, J. Fish. Res. Board Can. 1967; 13: 53-127.
38. Rawson DS. The net plankton of Great Slave Lake, J. Fish. Res. Board Can. 1956; 13: 53-127.

39. Zutshi DP, Subla BA, Khan MA, et al. Comparative limnology of nine lakes of Jammu and Kashmir Himalayas. Hydrobiologia. 1980; 72 (1-2): 101-112.
40. Whitton BA. River ecology. Blackwell scientific publications: London; 1975.
41. Ali M, Salam A, Iram S, et al. Studies on monthly variations in biological and Physico-chemical parameters of brackish water fishpond, Muzaffar Garh Multan. Pakistan. J. Res. Sci. 2005; 16(1): 27-38
42. Whittaker RH. Dominance and diversity in land plant communities. Science. 1965; 147: 250-260.
43. Hurlbert SH. The nonconcept of species diversity a critique and alternative parameters. Ecology. 1971; 52: 577-586.
44. Routledge RD. Bias in estimating the diversity of large, uncensored communities. Ecology. 1980; 61: 276-281.
45. Alatalo RV. Problems in the measurement of evenness in ecology. Oikos. 1981; 37: 199-204.
46. Hosamani SP. Phytoplankton Diversity in Lakes of Mysore District, Karnataka State, India. The Ecoscan. 2010; 4 (1): 53-57.
47. Palmer CM. Composite rating of algae tolerating organic pollution. Journal of Phycology. 1969; 5: 78-82.